Project Elaboration: Smart Water Purity & Storage Alert System for Households

1. Introduction

Access to safe and sufficient drinking water is a fundamental human need, yet it remains a significant daily challenge for many households in Bangladesh. Water sources, whether municipal supplies, tube wells, or stored rainwater, can be prone to various forms of contamination (bacterial, chemical, particulate matter). Furthermore, managing stored water levels to avoid unexpected shortages is a constant concern. Traditional methods for checking water quality are often inaccessible or impractical for daily household use, and manually monitoring water levels in large containers can be inconvenient. This project aims to address these everyday problems by developing an affordable, user-friendly electronic device and accompanying software to monitor household water purity and storage levels, providing timely alerts and peace of mind.

2. The Problem

- **Water Purity Concerns:** Households often lack real-time information about the safety of their stored drinking water. Contamination can occur from the source, during transportation, or within the storage container itself. This poses health risks, especially for vulnerable individuals like children and the elderly.
- **Unexpected Water Shortages:** Manually checking water levels in overhead tanks, drums, or traditional clay pots (kolshi) is often overlooked, leading to situations where households run out of water at inconvenient times.
- **Lack of Simple Monitoring Tools:** Existing water quality testing kits can be complex, expensive, or require sending samples to a lab. There is a need for a simple, in-situ device that provides immediate feedback.
- **Delayed Response to Issues:** Without continuous monitoring, issues like a sudden drop in water quality or a rapidly depleting supply might go unnoticed until it's too late, causing inconvenience or health problems.

3. The Proposed Solution

A **Smart Water Purity & Storage Alert System** comprising a compact electronic sensor unit and a user-friendly mobile application.

3.1. Electronic Device (Sensor Unit)

- **Core Functionality:** To be placed inside or attached to a household water storage container. It will continuously or periodically measure key water quality parameters and the water level.
- **Components:**
  - **Microcontroller Unit (MCU):** A low-power, cost-effective MCU (e.g., ESP32-C3, ESP8266, or a low-power STM32 variant) will manage sensor readings, data processing, power management, and wireless communication.
  - **Water Quality Sensors:**
    - **Turbidity Sensor:** Detects suspended particles, indicating physical impurities or cloudiness. (e.g., using an infrared LED and phototransistor).
    - **pH Sensor:** Measures the acidity or alkalinity of the water. (e.g., a compact glass electrode pH sensor or a solid-state ISFET sensor if cost-effective).
    - **Temperature Sensor:** Measures water temperature, which can affect other parameters and indicate stagnation. (e.g., DS18B20 waterproof sensor).
    - **(Optional/Advanced):** Total Dissolved Solids (TDS) / Electrical Conductivity (EC) sensor to measure dissolved impurities. Simple colorimetric sensors for specific common contaminants (e.g., arsenic, iron) could be explored for future iterations if low-cost, reliable versions become available.
  - **Water Level Sensor:**
    - **Ultrasonic Sensor:** Mounted above the water level, measures distance to the water surface (e.g., HC-SR04, JSN-SR04T - waterproof version).
    - **Float Switch/Sensor:** A simpler, mechanical option for discrete level indication (e.g., full, half, low).
  - **Wireless Communication Module:**
    - **Bluetooth Low Energy (BLE):** For short-range communication with a paired smartphone app. Ideal for low power consumption.
    - **(Optional):** Wi-Fi (if the MCU supports it, like ESP32) for direct connection to a home network, enabling remote alerts or data logging to a cloud service.
  - **Power Source:**
    - **Rechargeable Battery:** A long-lasting Lithium-ion or LiPo battery (e.g., 1000-2000 mAh).
    - **Solar Charging (Optional):** A small, efficient solar panel integrated into the device casing for autonomous operation, especially if deployed in outdoor tanks or areas with good light.

        - **USB Charging Port:** For conventional charging.
    - **User Interface (On-Device):**
        - **Multi-color LEDs:** Simple visual indicators (e.g., Green for safe/full, Yellow for caution/medium, Red for alert/low/contaminated).
        - **Small Buzzer:** For audible alerts for critical conditions.
    - **Enclosure:**
        - Waterproof (IP67/IP68 rated) and made of food-grade, non-toxic plastic (e.g., ABS, Polypropylene).
        - Designed for easy placement in various container types and for sensor exposure to water.

3.2. Software Components

- **Mobile Application (Android/iOS):**
    - **Device Pairing & Configuration:** Simple and intuitive process to connect the sensor unit to the app via BLE or Wi-Fi.
    - **Real-time Data Dashboard:** Displays current water quality readings (turbidity, pH, temperature, TDS if available) and water level (percentage, estimated volume, or simple status like Full/Medium/Low).
    - **Alerts & Notifications:** Customizable push notifications for:
        - Low water level (e.g., below 20%).
        - Water quality parameters exceeding predefined safe thresholds (e.g., high turbidity, abnormal pH).
        - Reminders for refilling or purifying water.
        - Low battery alerts for the sensor unit.
    - **Historical Data & Trends:** Simple graphs showing water level fluctuations and quality parameter trends over time (e.g., daily, weekly), helping users understand consumption patterns or identify recurring quality issues.
    - **Settings:** Allow users to set custom alert thresholds, preferred units, and notification preferences.
    - **Troubleshooting & Help:** Basic guidance on sensor maintenance or common issues.
- **Cloud Backend (Optional, for enhanced features):**
    - **Secure Data Storage:** Anonymized data on water quality and consumption patterns can be stored for users who opt-in, enabling more advanced analytics.
    - **Community-Level Insights:** Aggregated, anonymized data could potentially provide insights into local water quality trends (with strong privacy safeguards).
    - **Firmware Over-The-Air (FOTA) Updates:** For improving device functionality or fixing bugs remotely.

3.3. Conceptual Prototype Description

Imagine a compact, disc-shaped or cylindrical device, roughly 8-10 cm in diameter and 3-5 cm thick. It would be made of smooth, white or light-colored food-grade plastic. If designed to float, it would sit on the water surface with sensors extending downwards. If designed to be submerged or attached to the side, it would have appropriate mounting mechanisms or be weighted.

- **Visuals:** A few clearly visible multi-color LEDs on the top or side would provide immediate status: Green (water okay, level sufficient), Yellow (water level medium, or minor quality deviation – check app), Red (water level low, or significant quality issue – immediate attention needed). A small, integrated solar panel might be visible on the top surface if that feature is included.
- **Interaction:** Minimal physical interaction. Setup would be via the mobile app. The device would operate autonomously once configured.
- **Placement:** Easily dropped into a water drum, fixed inside an overhead tank, or attached to the side of a kolshi (with sensors appropriately positioned).

3.4. How it Solves the Problem

- **Peace of Mind:** Provides continuous monitoring, reducing anxiety about water safety and availability.
- **Early Warning:** Alerts users to potential contamination or low water levels before they become critical problems, allowing timely action (e.g., boiling water, ordering refills, cleaning the tank).
- **Health Protection:** Helps prevent waterborne illnesses by flagging potential quality issues.
- **Convenience:** Automates the tedious tasks of manually checking water levels and guessing water quality.
- **Data-Driven Habits:** Historical data can help households understand their water consumption and identify patterns in water quality, potentially leading to better water management practices.

This system offers a practical, affordable, and user-friendly solution to enhance household water security and safety in Bangladesh.